

## **ENVIRONMENTAL VISUALIZATION AND HORIZONTAL FUSION**

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## **INTRODUCTION**

The Environmental Visualization (EVIS) project is a collaborative effort among the Naval Research Laboratory, the Naval Undersea Warfare Center, and the Applied Physics Laboratory, University of Washington. The EVIS team, a multidisciplinary group of physical scientists, computer scientists, and human factors psychologists, is tailoring the weather and oceanographic information provided to military personnel. The participation of the EVIS team in the Horizontal Fusion (HF) program, (sponsored by the Assistant Secretary of Defense for Networks and Information Integration), has resulted in an innovative capability that provides mission critical environmental effects products via a web service oriented architecture. Personnel of the Multinational Forces-Iraq (MNF-I) are testing this new capability.

The EVIS project began in 1997 as an Office of Naval (ONR) sponsored basic research project that focused on the human systems component of the U.S. Navy meteorology and oceanography (METOC) community. Researchers investigated the weather forecasting task and the associated processes such as: gathering the necessary METOC data and information from both numerical forecast models and observations; processing that information; forming a mental model of the weather; and providing an external explanation of the weather or the ocean's effect on a warfighter's mission. Based on this research, an applied project was funded by the ONR Future Naval Capability program to help solve noted problems in the flow of information from the source to the end-user. In 2003, the EVIS project was selected for inclusion in the Horizontal Fusion (HF) program. EVIS was tasked with developing technology to provide mission-critical environmental information to the HF portfolio members and end users within a secure web services architecture.

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The EVIS capability developed for HF enables an authenticated user to securely access high-resolution METOC information from a remote server, create tailored products for mission planning, publish the specific effects, and do this more efficiently than is possible with the currently available production tools. EVIS provides portal and other Java-based access mechanisms to METOC data sources through a family of value-added web services that were developed to expose and process data for METOC impacts related to specific military mission parameters. Based on a matrix of mission effect rules that can be modified by the user, the EVIS Mission Effects Services (EMES) generates mission impact summaries and related map image overlays that are available and advertised throughout the networked enterprise.

## **HORIZONTAL FUSION**

As stated on the Horizontal Fusion public web site, this program,

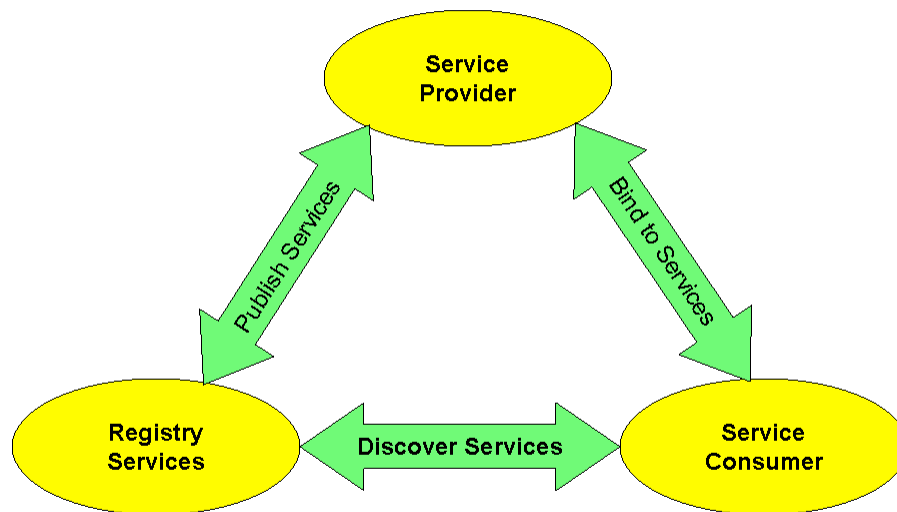
“...provides a foundation for effective information sharing through a framework of standards for interoperation. Portfolio management helps preserve legacy investments and focuses technology effort around the persistent availability of information rather than the perpetual replacement of systems. Time frames in a world of asymmetric conflict are far too short to allow for adaptation or replacement of systems. The benefits of information sharing are measurable:

- Fast access to more timely and accurate data
- Lower probability of decision-making error and, worse, operational risk
- Lower cost to use military force
- More accurately targeted force/higher probability of success
- Shorter time to mission goal; lower risk to U.S. and coalition forces.”

## **Service Oriented Architecture**

The key systems-related decision of the HF program was to connect a variety of capabilities via a Service Oriented Architecture (SOA).

One way to describe SOA can be seen in figure 1, commonly called the “SOA Triangle.” Service consumers locate service providers by means of a registry in which the current providers’ services are listed. Examples of simple services can be things such as receiving a map of a location or an updated time check.



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Figure 1. The Service Oriented Architecture triangle

Figure 1 is simple in principle, but there are many pitfalls in its implementation. The overall approach may be described as:

- Provider creates some service available for consumption
- Provider creates “registration documents” and registers these with some “registry service”
- Consumers, looking for that particular type of service, locate binding information via the registry service
- Consumers then bind (based on the indicated protocol in the registry documents) with the producer, and consume the product service

It must be realized that an SOA is a series of guidelines, not a rigid specification, although general principals are adhered to and discussed here. The architecture may be distributed over numerous servers running anywhere on the network (in the case of deployed HF services, on the DoD SIPRNET). Services implemented in many different languages and running on various operating systems and platforms dictate an implementation neutral specification. Most of the providers break down their overall service definition into a number of granular services for re-composition (building new services) and reuse. Because components are very loosely coupled, there is a great degree of flexibility in how services are combined and incorporated at a later time. Lastly, services are registered in a uniform way, so they may be discovered by potential users via the registration service.

The participants involved in the HF portfolio offer a large number of varied services, ranging from real-time streaming video (such as from a Predator flying over Iraq), to a

Defense Intelligence Agency (DIA) database of “persons of interest” and their whereabouts, to natural language translation services, to, in the case of EVIS, METOC information and its impact on various types of military missions. As more and more participants become involved, it seems clear that the benefits of an SOA will validate this choice of architecture. Key components of an SOA that are implemented by HF are described below.

### *Registering and Discovering Services*

The primary method by which services are registered and discovered (located) in an SOA is through common registries based on the Universal Description, Discovery, and Integration (UDDI) specification. UDDI is, in effect, like a phonebook for web services; both the service location and a technical description of the service offerings are available.

The UDDI specification relies on a categorization system based on taxonomies. Through the use of taxonomies, definitions, relationships, and descriptions of business entities and their locations, service binding information may be formally expressed. Over the last three years HF data providers have collaborated on new discovery taxonomy. This taxonomy was provided to the Assistant Secretary of Defense for Networks and Information Integration (ASD/NII) Taxonomy Focus Group and has since become part of the group’s core taxonomy. In time, many see this effort evolving into the core DOD taxonomy and being ubiquitous on the Global Information Grid (GIG). Because “weather” incorporates many diverse intellectual concepts involving the physical world, it is especially difficult to derive taxonomic descriptions that capture the salient points of meteorological phenomena and their relationships to events. A major focus of EVIS development has been to codify weather and oceanography and their relationship to and impact on missions and assets within the military domain; this effort is more fully explained in the section on EVIS Rules.

### *Federated Search – Discovering Content*

Another method of discovering services and their content has been implemented in HF through a next-generation knowledge discovery framework called Federated Search. A virtual information space, called Collateral Space was developed for the HF portfolio. Collateral Space contains a collection of specialized data search engines; data and information from various service providers have been registered using a software construct known as the Registration Web Service (RWS). Complex queries may be initiated at any point in Collateral Space, and results are obtained by software called the Search Web Service (SWS).

Query initiation takes place by a user first posing a natural language query to IFIS (the Intelligent Federated Index Search). The process unfolds as follows: (1) IFIS receives a natural language query and normalizes it into a standard formalization, from which the semantics of common terms and keywords may be recognized. (2) IFIS matches these terms with information provided by data providers who have registered with the Collateral Space, and the normalized queries are then forwarded to the pertinent data

providers via the SWS; (3) data providers match the query to various data products within their domain and return results via the SWS; (4) the IFIS engine conducts initial post processing; and (5) a ranked list of the query results is presented to the user. A detailed example of a query posed for environmental mission effects products, is presented later in the paper.

Federated Search allows users to search through Collateral Space data that is both structured and non-structured, and multiple searches may be initiated from a single point. Since only the data providers deemed relevant by analysis of the semantics of the query respond, much of the sorting and correlation that would be necessary by a user using ordinary search engine technology (e.g., Google) is eliminated. A further feature of IFIS allows user customization of query normalization routing by defining a search profile that may incorporate prior knowledge. Date and geospatial constraints can also be put into the query; a user can ask for data that is very recent or that is relevant to a specific geographical area. The Federated Search process supports access control (discussed in *Security* in the following paragraphs), so only users with proper security credentials (role, citizenship, clearance) may obtain results at various security classification levels. The returns from the data provider include a relevance score that can be displayed and used to sort results. A final feature of the IFIS process is the ability to deal with military acronyms common in almost all military queries. IFIS uses an elaborate ontology to cast semantic terms to and from a common lexicon.

### *Security*

One of the initial goals of Horizontal Fusion was to develop and demonstrate security capability beyond “system-high” including a cross-domain capability using COTS/GOTS software and hardware rather than more trusted operating systems. The goal was security controls that would perform authorization and authentication of all users, data and services within the execution chain (i.e., beginning with a user logon, to service or content discovery, to information request, to final delivery of a data product to the user). To achieve this, a set of security specifications was developed which detail the services to be invoked and to what extent each service contributes to the overall security.

Early implementation efforts began by requiring web service calls to be made using Hypertext Transport Protocol Secure (HTTPS) and extending the Lightweight Directory Access Protocol (LDAP) standard. To achieve this, the Defense Information Services Agency’s (DISA) Global Directory Service (GDS), which contains information about all DoD personnel who have obtained DoD Public Key Infrastructure (PKI) Certificates, was incorporated as the core schema for the HF LDAP. Further extensions were made since DISA’s GDS did not support all features needed for an augmented Discretionary Access Control (known in HF as DAC+) such as user authentication and clearance capability.

To make security software development more uniform throughout the HF program, two security software development kits were produced: one by DIA and another from DISA’s Net-Centric Enterprise Services (NCES) group. These handlers were plugged in at

various levels in the service chain and were able to implement most of the call-outs for security adjudication.

Security adjudication utilizes several services: Certificate Validation Service (CVS), Principal Attribute Service (PAS), Policy Decision Service (PDS), and Classification Policy Decision Service (cPDS). The security handlers managed the task of calling CVS to validate the PKI certificate of the user and calling PDS to determine the role-based authorization of the user (i.e., whether the user can have access to the service requested). PAS is utilized to retrieve information about user attributes and these are retrieved by the enterprise LDAP.

In HF, the EVIS application gets information from LDAP through a convenience application that the portal supplies, (i.e., an RBACPortalBean). Finally, the cPDS implements decision rules for security access policies for the enterprise. These decision rules check the validity of security labels. For example, the rules ask if a specific combination of classification level, dissemination control, and releasable markings is a valid classification. The cPDS is also used to check relationships between the classification of data and the user's credentials and determine whether the data can be released to the user. While simple to state, security adjudication is extremely complex given the various levels of U.S. and foreign security classifications, rules for classification aggregation, and rules for classification dominance of a widespread clientele on the GIG.

The HF program has been successful in its initial implementation of attribute-based access controls, especially Role-Based Access Control (RBAC). In the case of EVIS, a user with the credential of "user.analyst" may request archived effects products. However, a "user.analyst.weather" credential (that of a trained METOC forecaster) is necessary for the analysis and production of content describing the environmental impacts on mission variables. Obviously, the continual success of this approach will depend on the dynamic updating of user roles as personnel shift in and out of theater operations.

## **THE EVIS INITIATIVE IN HF**

### **The EVIS Portlet**

#### *Portals and Portlets*

A web portal is designed to provide personalized capabilities to its users. The users sign onto the portal to start the session and the portal decides which distributed applications to present to the user based on the user's status or role acquired from an access control service. The user is required to authenticate only once, thus giving him access to all allowable applications referred to as single sign-on.

Although early web portals have been successful on a hit or miss basis such as Yahoo!, Google, AOL, and MSN, the industry is now shifting to the enterprise web portal, or "enterprise web." The use of a private web portal to unite the web communications and

shared thinking inside a large corporation has begun to be seen by many as both a labor-saving and money-saving technology. Some corporate analysts have predicted that corporate web portal spending will be one of the top five areas for growth in the Internet technologies sector during the first decade of the 21st century.

The most important features of enterprise portals are:

Single touch point —the delivery mechanism for all business information services.

Personalization —portal members subscribe to specific types of content and services. Users customize the look and feel of their environment.

Collaboration — portal members communicate synchronously (chat, or messaging) or asynchronously through threaded discussion and email digests (forums).

Content and document management — services that support the full life cycle of document creation and provide mechanisms for authoring, approval, version control, scheduled publishing, indexing, and searching.

Integration — the connection of functions and data from multiple systems into new components or portlets.

### *The Implementation of a Mission Effects Portlet*

The EVIS system is a collaboration between a data-facing service and a user-facing service. The EVIS portlet resides as a subcomponent in the larger HF MARS portal. The EVIS portlet provides several layers of capability depending on the user's role. Designated weather forecasters (role: *user.analyst.weather*) have access to the full capability to make mission effects products, while operational users or analysts (role: *user.analyst*) have the ability to only view the products made by the weather forecasters.

The EVIS portlet, called the EVIS Mission Effects System (EMES), is a decision tool designed to aid users in understanding the effect of the environment on operational missions and is developed by orchestrating the suite of EVIS web services. The EMES product provides both an overview in matrix or spreadsheet format of the environmental effects on a particular mission, plus a visual representation of the environmental effects over a geographic area of interest (AOI). The geographic product is a shaded contour map overlay that shows a yellow shaded area where the selected environmental parameter could cause a marginal impact on military operations, and a red shaded area where the impact is expected to be severe, based on a threshold comparison of user-defined limits and numerical model analyses and forecasts. A color-coded spreadsheet or matrix, listing the mission parameters and the environmental impacts for each forecast time, is also generated. Each cell in the matrix is hyperlinked to a graphic product that represents the same time period and threshold parameter. Products are saved on the EVIS server and accessed via the EMES Review page(s).



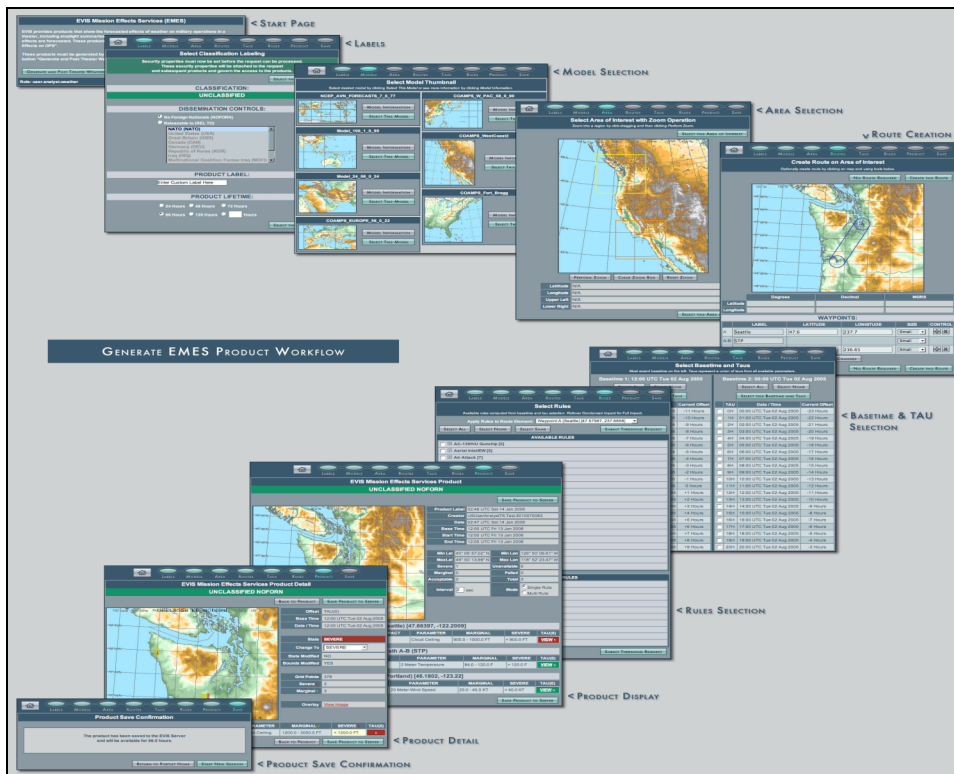


Figure 2. EVIS Portlet Workflow

Figure 2 represents a user's workflow (from top left clockwise around to bottom left) when generating an EVIS Portlet product. Once the portlet is started, the Labels page provides user-definable classification and dissemination controls for the final product created in a session.

The Model Selection page returns a series of model "thumbnails" representing various geographic areas where environmental numerical model information of interest to the EVIS user is available. Within the thumbnails there may also be colored rectangles representing various mesoscale model nests. Please see Figure 3 for a larger view.

A Model Information page (not shown) provides metadata information about the parameters contained in a given model. This page is available for each model in the Model Selection page.

The Area Selection page allows users to specify a smaller region of a geographical area than the model provides by default. This is useful for zooming in on the map and generating a product page that provides information about a specific area.

The Route Creation page allows users to create a route on top of the area they have selected. A route is defined by a series of waypoints that are connected by paths. Each route component can be associated with individual impact thresholds. Later, when the threshold effects are returned, the results will correspond only to the route elements users have added.

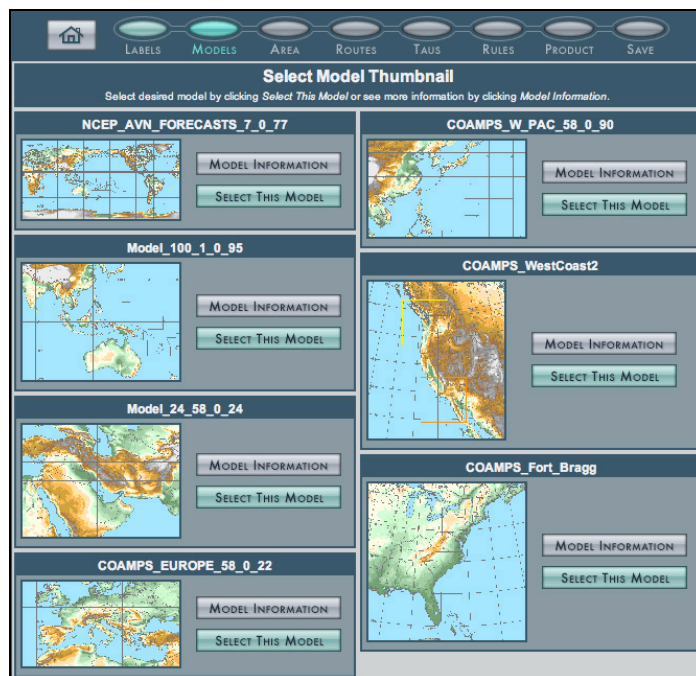


Figure 3. Example of EVIS Portlet model selection.

The Basetime (forecast times) and TAU page (not shown) provides users the opportunity to select one base time (starting point) and multiple TAUs (forecast time offsets) for a forecast. Each TAU selected will produce a forecast for the end product.

Through the Rule Selection page (not shown) users can specify multiple rules to be displayed in the final product. As described below, the RP-1 application is used to provide rule services for EVIS. Each rule requires both a marginal and severe value in order for the server to compute effects and create a threshold image. The final product is an image for each TAU and Rule (TAU-Rule) combination. For example, if three TAUs are selected from the Basetime & TAUs page and five rules are selected from Rule Selection, the final product will provide a total of 15 cells, with each valid cell containing a link to the associated threshold image.

The Product Display page (not shown) presents the results of the current session in table format. There are two types of information displayed on this page. The first type is user-selected data. This page displays: who the user is, when the product was created, what basetime was selected, the latitudes and longitudes of the selected geographic area, and a map of the selected geographic area.

The second type of information is the result of each TAU-Rule combination. The server applies the user-defined marginal and severe values of each rule to each TAU and displays a table summarizing the results. Each cell in the table displays a color representing the most severe state in each TAU-Rule combination: Green – acceptable; Yellow – marginal; Red – severe; and black – no data available or server failed on request. If a route was created, the data is further separated with each route element

having its own table with its own rules and threshold results. If no route was requested, then all rules will be in a single table.

The Product Detail page displays the geographic map area for the selected TAU-Rule cell with a marginal (yellow) and severe (red) threshold color overlay. Please see Figure 4. This combined image represents where the parameter is forecast to exceed the values in the marginal and severe fields for this TAU-Rule combination. The Confirmation page confirms that the product resulting from the current session has been saved to the EVIS server, and will be available in the REVIEW EMES PRODUCTS portlet.

Note that since the EVIS Portlet runs inside the user's browser there is no additional software required. The EVIS Portlet has been tested in many browsers including Internet Explorer, Mozilla, Netscape, Firefox, Opera, and Safari. The most recent release of any browser of choice is recommended.

The EVIS Portlet demonstrates one orchestration of the EVIS back-end web services. Other orchestrations are possible and this powerful construct made possible using web services has been demonstrated by other applications that have utilized the EVIS back end services and integrated components into their feature sets. Similarly, using web services, the EVIS Portlet could access an available web mapping service and demonstrate cross-application orchestration.

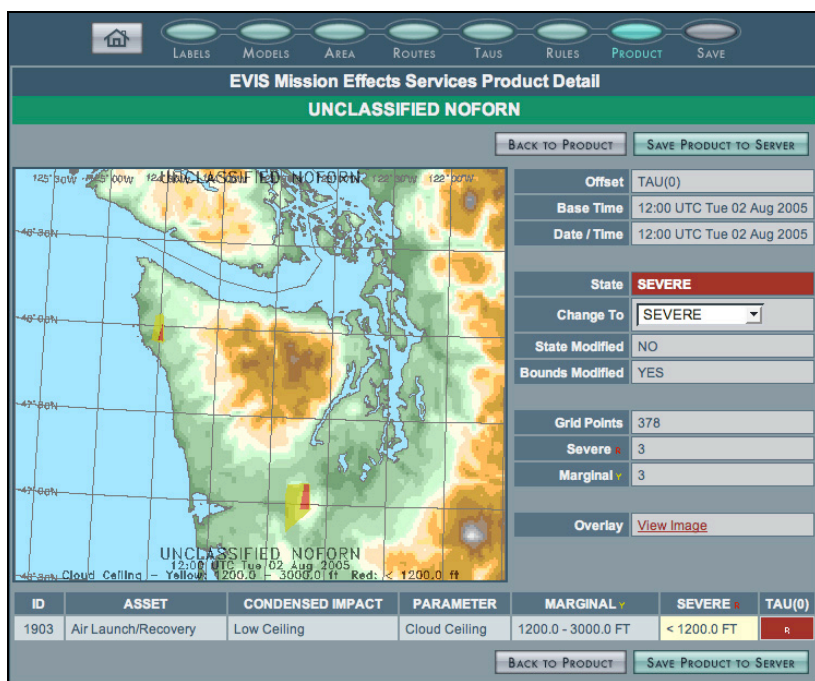


Figure 4. Example of EVIS Portlet mission effects product.

## The EVIS Server

The core data engine of EMES is the EVIS web server, maintained and supported at the Fleet Numerical Meteorology and Oceanography Center (FNMOC). The EVIS server

pulls raw environmental data from multiple data sources, performs various operations on the raw data, and presents actionable information via re-usable SOAP web services to external clients. The primary client application is the EVIS Portlet described above, running in the HF MARS Portal, which allows the authenticated, authorized forecaster in the field the ability to create and store mission-tailored METOC threshold products using EVIS web services. The mission impact products are available to warfighters and decision makers both through the EVIS web server itself and through the EVIS Federated Search service, and are consumed by the Federated Search Portlet and the National Geospatial Intelligence Agency Services (NGS) Portlet. NCES Core Security Services ensure that the correct portal member has access to what it should, and that all communications between the server and client are validated, digitally signed, and authorized. This architecture is displayed in Figure 5.

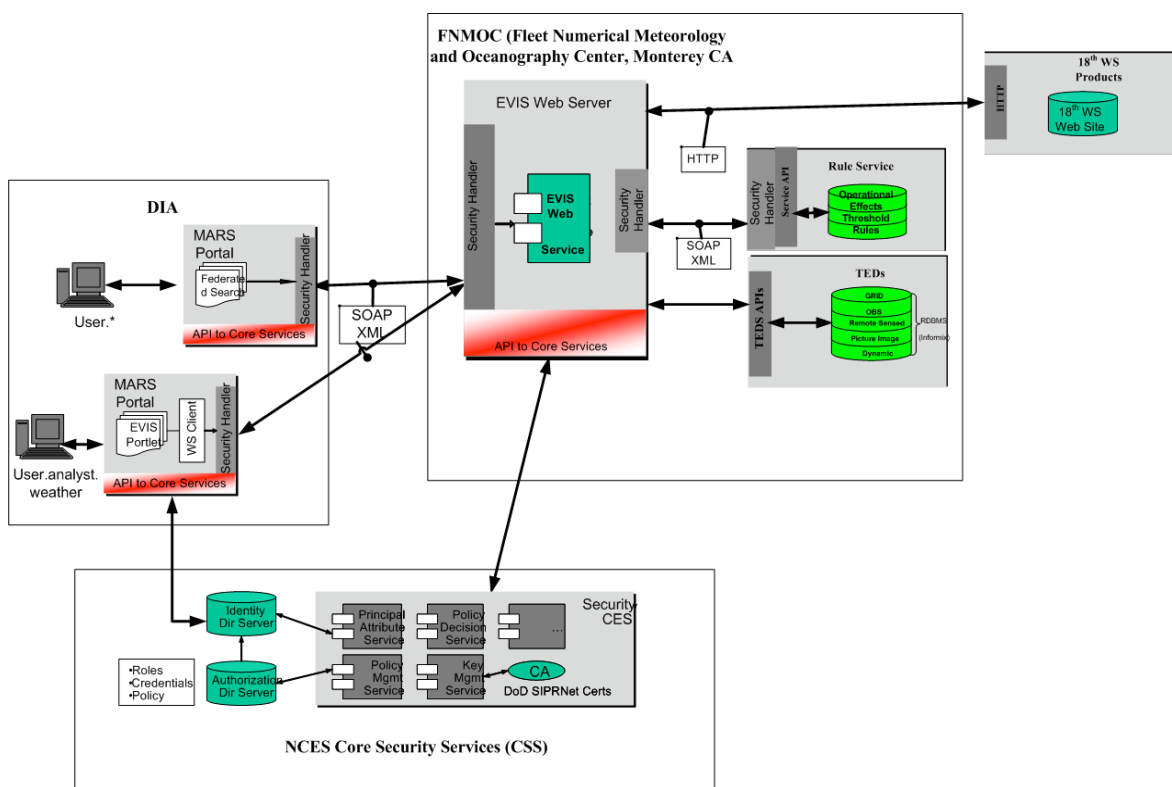


Figure 5. The systems architecture for EVIS as deployed in Horizontal Fusion.

To the outside world, the EVIS server provides a set of secure web services that allow clients to identify the METOC information available, and to create, store, and search mission-specific threshold products. Internally, the EVIS server consumes mission impact rule data, raw model gridded analysis and forecast data, SOAP web services, and externally-created METOC products to fuel its analysis and respond to service requests. Through the use of SOA principles, the EVIS server is able to support ongoing operations by not only allowing mission-tailored METOC threshold products to be created and disseminated, but by adapting the services for over-the-network interface with established

warfighter tools and processes. These server capabilities assist in the search and retrieval of warfighter products using the HF Federated Search tool (IFIS).

### *Reusable Services*

The EVIS web services were designed to automate the laborious and error-prone manual process of creating mission-specific METOC threshold spreadsheet products to brief the warfighter. By designing the services as machine-consumable SOAP web services with published service descriptions and XML schemas, multiple client types can consume the web services and, thereby, deliver additional value to the users of those services. The EVIS reference client (EMES – EVIS METOC Effects Service) uses the services to walk a forecaster through the orchestrated workflow process of creating, customizing, and storing a set of overlays showing the effects of weather and oceanography on an area for a particular set of mission parameters. As an example of the power and flexibility of the SOA, an independent mission planning application named REDS (Real-Time Execution Decision Support) used several EVIS services in September, 2003 to layer METOC effects into its mission status and analysis display tool for a Net-Centric Capabilities Pilot (NCCP) Sea Trial. As mentioned above, the National Geospatial Intelligence Agency (NGA) developed a portlet in Horizontal Fusion that consumes the EVIS search service and displays its products on a graphical map viewer along with the results from other content providers.

Each EVIS service (Table 1) is protected behind DIA's security handler that implements the NCES Security Services specification that involves the Web Service-Security and Security Assertion Markup Language (SAML) standards. The handler ensures that each requestor's clearance and citizenship information is included with every request, in addition to the message classification information. EVIS services use this information to limit response to the request by removing any inappropriate material. Furthermore, as part of the HF security requirements, all data at rest on the EVIS server are labeled by digitally assigning the files with their classification information. Thus, every access to this secured information requires clearance and citizenship information to ensure valid retrieval. Also, when accessed, the data are checked for evidence of tampering.

Table 1. Available EVIS web services and their descriptions.

<i><b>Service</b></i>	<i><b>Description</b></i>
ArchiveService	Archives products created by the portlet on the server for retrieval through the local EVIS review web interface
PingService	Checks the server for data source (TEDS) availability.
RulesService	Returns METOC thresholds / rules, usually from RP-1
SatelliteImageService	Returns available satellite image URLs for configured areas.

<i><b>Service</b></i>	<i><b>Description</b></i>
ThresholdAnalysisService	Takes an area, a list of METOC limits, and one or more times, and calculates the METOC thresholds. Threshold images that describe “red” (danger) and “yellow” (caution) impacts are returned.
ThumbnailImageService	Returns detailed information for each requested model and returns a list of URLs for thumbnail images.
ThumbnailSummaryService	Returns metadata on all available areas where METOC model information is available.
ZoomService	Performs a zoom of a given location and returns a URL pointing to an image of the zoomed area.
SearchMessageReceiverService	Searches archived products for the given criteria and returns matches that include summaries and URLs that point to the product.

### *Data Source Integration*

Since EVIS is a content provider, not a raw data source, it must retrieve METOC model data, validated METOC threshold rules, and external METOC products from available sources for its analysis and operation. Each data source accessed uses the highest level of security available, ranging from a simple HTTPS request to a full NCES Security Services-protected SOAP call that passes along security clearance and classification information. This integration is important as it shows that EVIS is just another consumer of services in the Service Oriented Architecture, aggregating retrieved information to build new value-added products for another consumer.

EVIS leaves the collection and management of validated METOC thresholds to the Reference Publication 1 (RP-1) application. RP-1 is a web-based application that serves as a collection and authorization point for METOC threshold information and it includes processes to validate and organize the thresholds by tying them to assets, missions, and METOC parameters. EVIS retrieves its thresholds from the RP-1 SOAP services hosted at FNMOC and allows the user to customize rule sets by linking directly to the RP-1 web interface. The communication between EVIS and RP-1 utilizes NCES Security Services.

The other key ingredient for the generation of METOC impact products is the raw model analysis and forecast gridded data. EVIS utilizes the Tactical Environmental Data Server (TEDS) hosted at FNMOC that collects and distributes, among other data types, model data from COAMPS<sup>®</sup> (Coupled Ocean/Atmosphere Mesoscale Prediction System) and NOGAPS (Navy Operational Global Atmospheric Prediction System) within a DOD standard relational database. The integration of additional data sources for EVIS is currently under development. These new data sources include TEDServices (also known

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COAMPS<sup>®</sup> is a registered trademark of the Naval Research Laboratory.

as Virtual Natural Environment – Net-Centric Services: VNE-NCS) and flat file output directly (bypassing the database).

Finally, since EVIS is one of several existing METOC effects products, it has been adapted to retrieve external products over the network and make them available through the HF Federated Search service along with the portlet-created products. In another example of the extensibility of the SOA, EVIS has been enhanced to include a process that can periodically retrieve web-accessible metadata files describing these external products, and add the metadata information to its own search catalog. EVIS also can use generic product templates stored locally, but updated periodically, with information gleaned from external products (such as valid time). Using this technique trusted off-site content can be exposed to the enterprise using the Federated Search capability. This is a powerful method to interact with a larger user community.

### *Operational Deployment*

The EVIS server, as a Horizontal Fusion portfolio member, is currently deployed operationally at FNMOC, Monterey, CA in support of the Multi-National Forces – Iraq (MNF-I), with the software maintained and the configuration managed by FNMOC personnel. EVIS services provide a reach-back capability for environmental mission impact products, including those produced in theater using applications other than EVIS. This enhanced capability highlights the flexible Services Oriented Architecture approach adopted by EVIS and HF.

When EVIS management first learned in February 2005 that HF was targeting operational support for the U.S. Army 18<sup>th</sup> Airborne Corp (ABC), they met with the Air Force 18<sup>th</sup> Operational Weather Squadron (OWS) assigned to provide METOC support to the 18<sup>th</sup> ABC. They learned that the 18<sup>th</sup> OWS already had a process in place for generating METOC effects products that resulted in a single PowerPoint slide they made accessible on their local web site. While the 18<sup>th</sup> OWS was interested in using EVIS in the future for point-and-route forecasting, they were not willing to replace their existing product. But their product was only accessible if one knew the URL, and it was available only to the 18<sup>th</sup> OWS; the page was tucked away on the MNF-I website, inaccessible to the untrained user. EVIS managers saw an opportunity to leverage their search infrastructure to retrieve metadata about the 18<sup>th</sup> OWS product, thus making it available through the HF Federated Search service. Now, the MNF-I official METOC effects analysis can be easily retrieved from a simple Federated Search portlet and can be displayed graphically along with other pertinent search results including sensor video feeds, intelligence reports, and translated documents. Further, the 18<sup>th</sup> OWS can now access other useful data and products available within the larger community.

### **EVIS & Federated Search**

The use of the HF Federated Search capability to make METOC mission impact products available for global searching is a critical accomplishment for HF. Normalized queries are routed to EVIS from IFIS and are broken down into components and compared

against metadata describing METOC products on the EVIS server. Matches are used to select product URLs, which are returned to the Federated Search user sorted by relevance, allowing for the discovery of METOC information by users unfamiliar with METOC services and products. This ability of data search and discovery over a diverse network of users and data providers is an essential component of the HF program.

The EVIS federated search service is designed not only to search through the products made using the EMES application, but also search through other available non-EMES environmental impact products. In particular, using the metadata scheme that we developed for environmental impact products, our search service determines whether specific weather impact products made daily for Iraq are relevant to user queries, and return the URL to a specific operational product if appropriate.

All of the HF Federated Search data providers were tested for data quality and compliance to the query syntax specification (ability to handle Boolean queries and date/geospatial constraints). EVIS achieved the highest overall score for data quality and passed all of the query syntax tests (EVIS was the only initiative that has passed all of these syntax tests from the onset). Data quality was scored by a team that included retired military personnel who rated the products that were returned by the data providers. Given relevant queries (e.g., Iraq weather, Baghdad weather, etc), the EVIS server returned links to the daily tactical forecasts published by the 18<sup>th</sup> Weather Squadron for Iraq, with a summary, a calculated relevance score, and date information about when the product was posted and is valid.

Data quality ratings were placed on the following attributes (EVIS scores are in parentheses).

- Relevance of results to query (4 out of 5)
- Timeliness of results (5 out of 5)
- Results well-described by title and description (5 out of 5)
- Appropriateness of relevance score (5 out of 5) (a relevance score of 0-100 has to be returned for each hit)
- Value of results to the intended user (5 out of 5)

The EVIS Federated search capability can be called by any application that implements the Search Web Service (SWS) specification. Currently, there are two applications that implement this specification, and the user interfaces are very different so as to allow different searches, graphical maps or area names. The following section shows how each application can be used to discover Iraq theater weather products that are made daily by personnel assigned to the Staff Weather Office of the MultiNational Corps-Iraq.

#### *Discovery through the National Geospatial Agency's HF Portlet.*

This method uses a graphical application to display the results of the search. Users open the NGA's HF portlet, select the EVIS server as a data source, and enter a search for weather forecasts (e.g., "weather in Iraq," as illustrated in Figure 6, left.) As illustrated in



Figure 6 on the right, the search will return overlays for products that are available in the AOI, indicating the notional areas (shaded) covered by each forecast product.

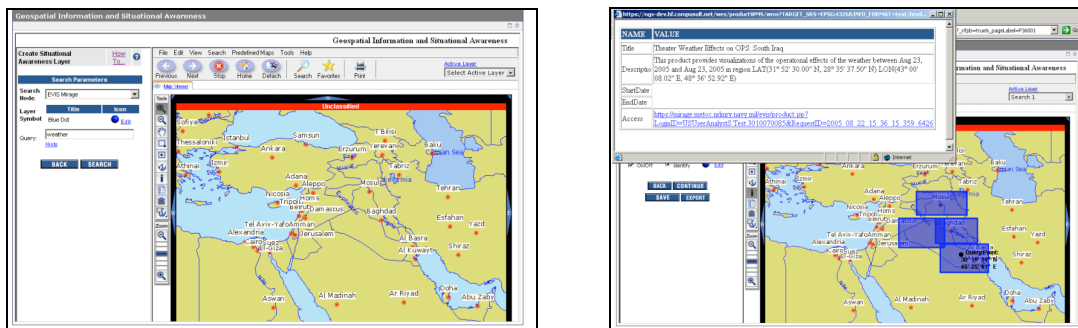


Figure 6. NGA HF portlet (left and right) showing a representative set of results illustrated by overlays (shaded areas) of the forecasted areas (i.e., North, West, East, and South Iraq). The popup details the product represented by the lower-right overlay, South Iraq.

By selecting within one of the overlays, users can ask for the product detail and a popup will open with a summary, start and end times for the forecast, and a URL to retrieve the product. By selecting the URL, the product will be delivered to users' desktops.

### *Through the Federated Search Portlet.*

To utilize the other method, users open the Federated Search Portlet on the Horizontal Fusion portal and enter a search string such as "Iraq weather."

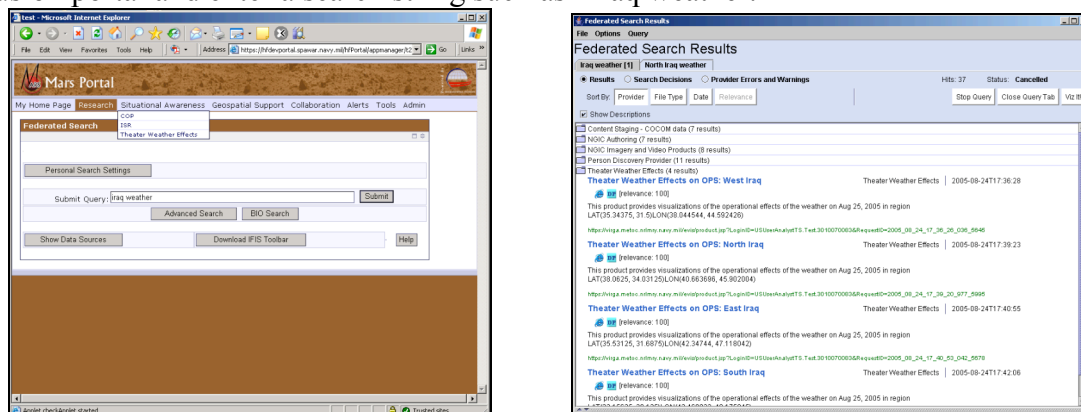


Figure 7. Federated Search portlet on the left, and an illustrative results window on the right.

The search application will generate queries to all data providers, including EVIS, and a results window will show hits from the data provider including one entitled, "Theater Weather Effects," which refers to the EVIS server. By opening the "Theater Weather Effects" folder, users see details of the hits, and by selecting one of the links, the product will be delivered to users' desktops. The results detail includes title, summary, relevance score, product MIME type, and data about the date of the product.

The EVIS server can support a wide variety of natural language query forms including all of the following whether entire sentences or just phrases. The last example is illustrative of the complex Boolean queries that can be supported. In this case, the user is searching for high cloud cover and high wind speed conditions that are not restrictive.

- Is there a severe impact of high temperature on operations?
- Is there a severe effect of high temperature on personnel?
- What is the impact of high temperature on personnel?
- Does high temperature impact personnel on 18 Apr 2005?
- What is the effect of cloud cover at 2300N120E
- Cloud cover at 2300N12000E
- Severe temperature impact on 18 Apr 2005
- Marginal temperature effect on 02/22/2005
- Severe impact to visibility after Apr 18 2005
- Severe temperature effect between April 17 2005 and Apr 19 2005
- Cloud cover at 2300N12000E?
- (NOT severe) AND high ("cloud cover" AND "wind speed")

## **SUMMARY**

By its participation in the Horizontal Fusion (HF) program, the EVIS team was able to extend their mission effects capability, which was originally intended for naval weather forecasters, into a tool that is now available to the joint services and other non-DoD related security services. The cutting edge SOA infrastructure developed by the HF program allowed the EVIS team the opportunity to move critical METOC information into a secure and discoverable web service environment. The HF program has helped chart a path that could provide the way forward to further expansion of information sharing across multiple domains.

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